Using Neutrinos from the Booster Beamline in the SciBooNE hole

Zelimir Djurcic

Argonne National Laboratory

in collaboration with

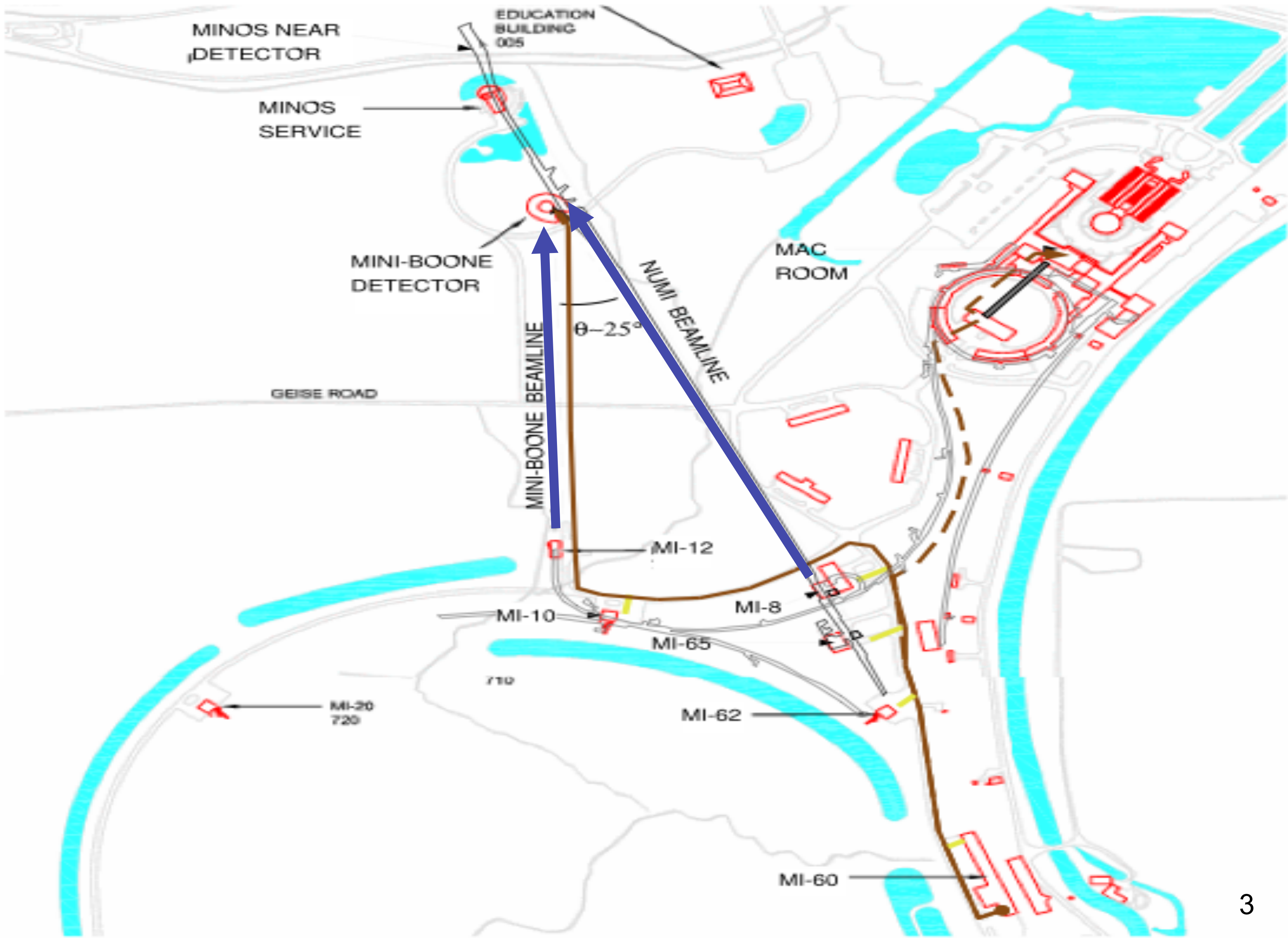
G. Davies (Iowa State), H. Frisch (U Chicago) M. Sanchez (Iowa/ANL), M. Wetstein (U Chicago/ANL), T. Xin (Iowa State)

2011

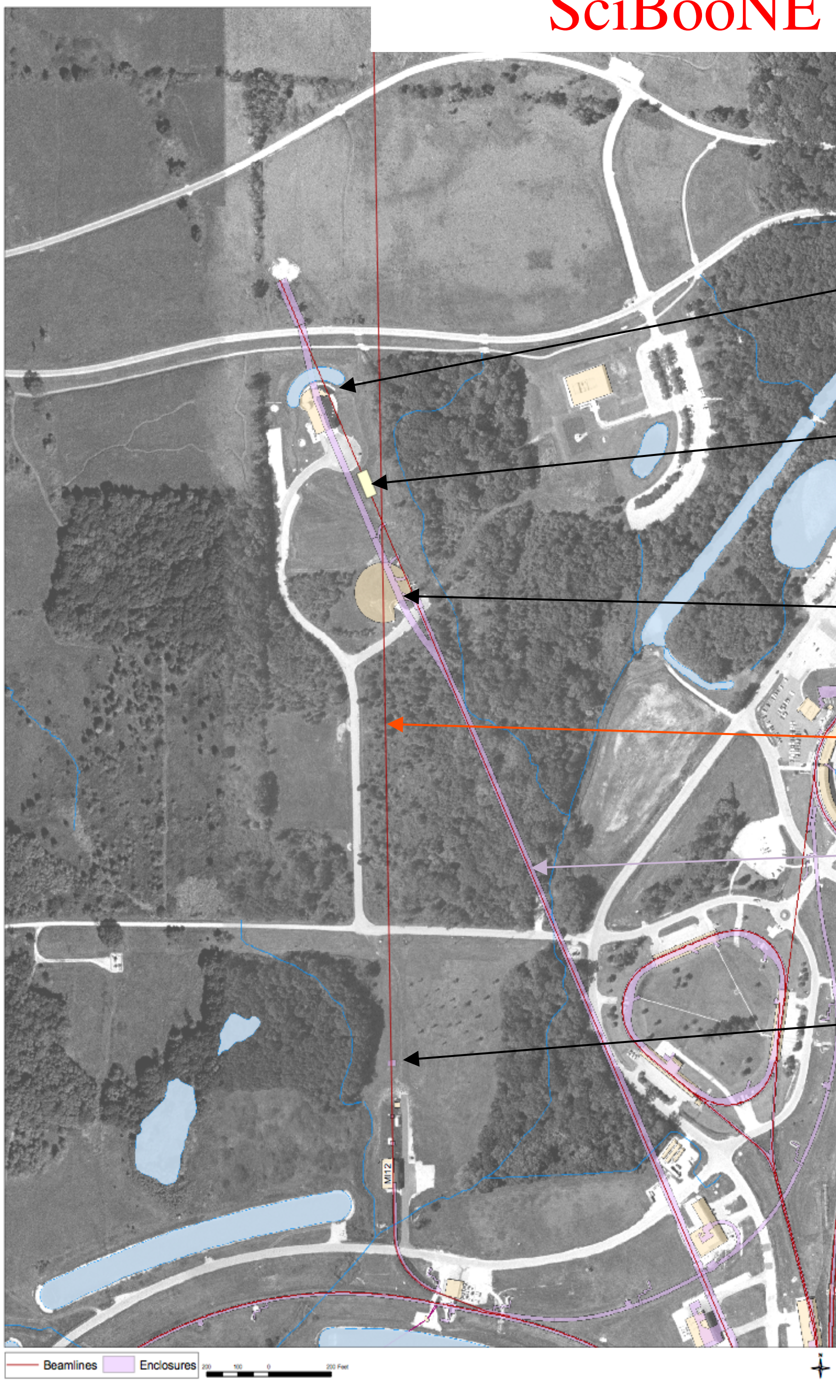
Content of this Presentation

-Booster beamline info.
-Location of the former SciBooNE enclosure.
-Dimensions of the enclosure.
-Neutrino flux from the Booster beamline at the enclosure.
-Calculation of the rate of neutrino interactions in oil and water.
-Goals.

Fermilab Neutrino Beams



SciBooNE Hole Position



MINOS surface building

NOνA NDOS detector

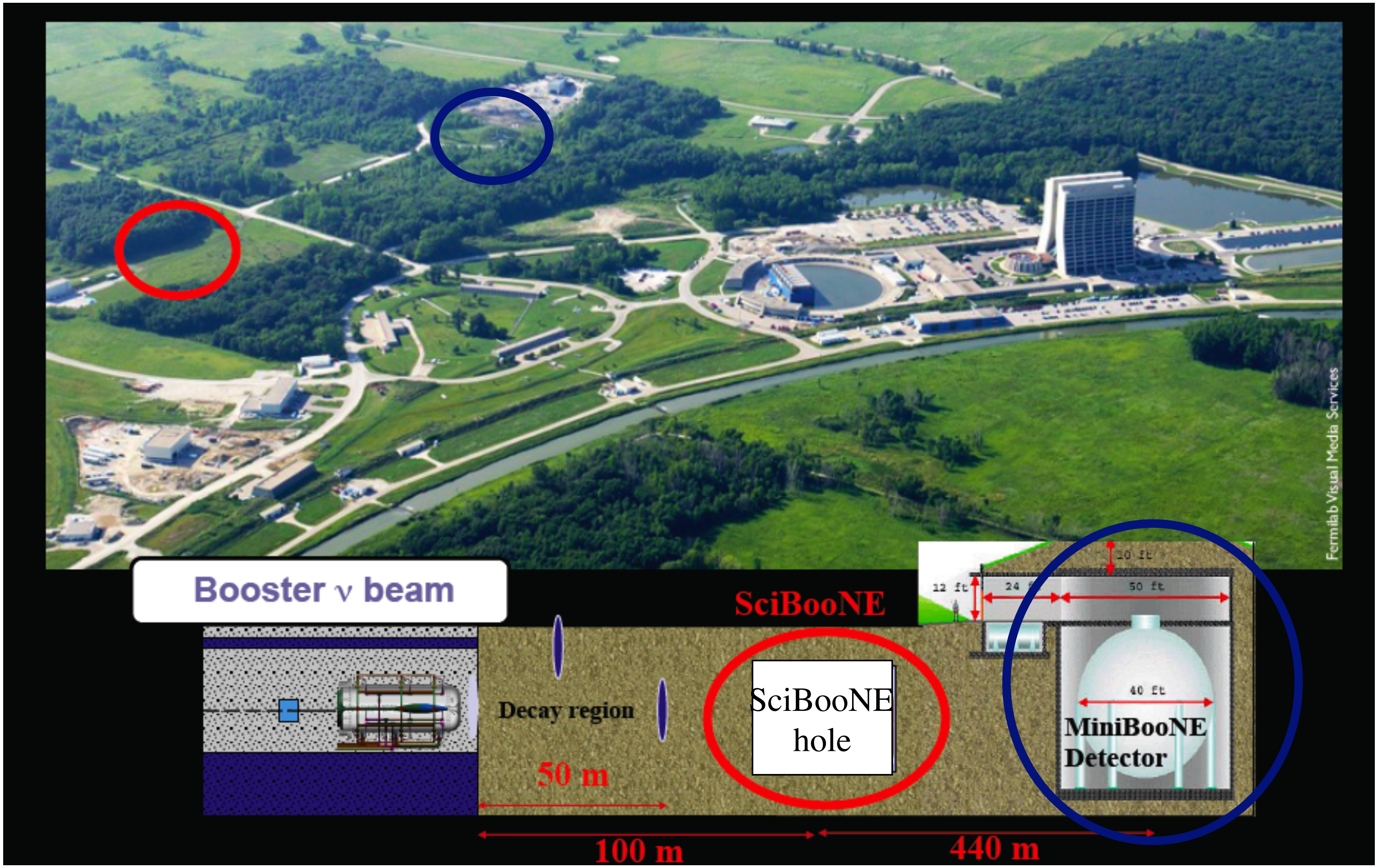
MiniBooNE detector

Booster ν beam

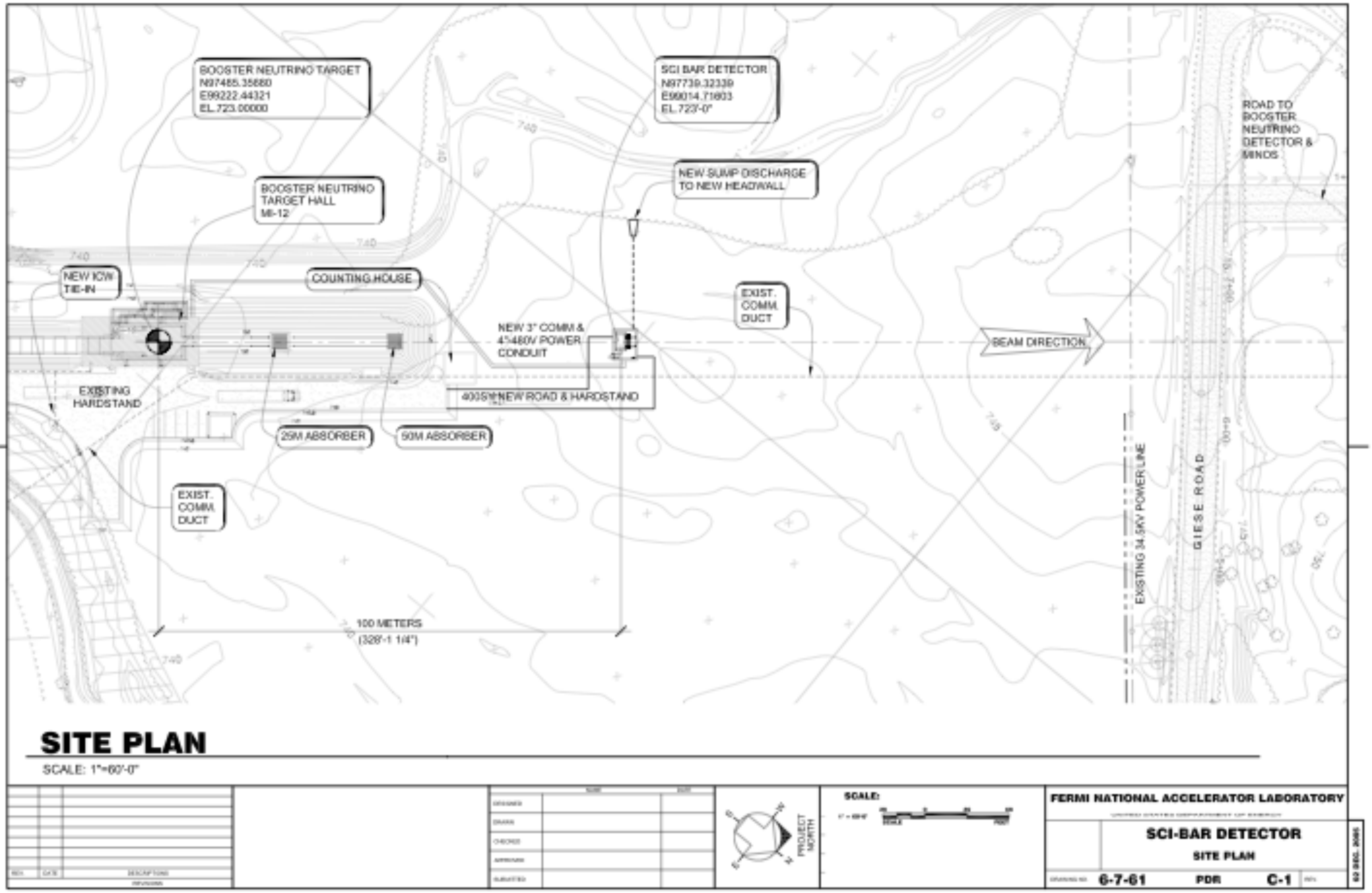
NuMI ν beam

SciBooNE enclosure

Booster Beamline and SciBooNE Hole

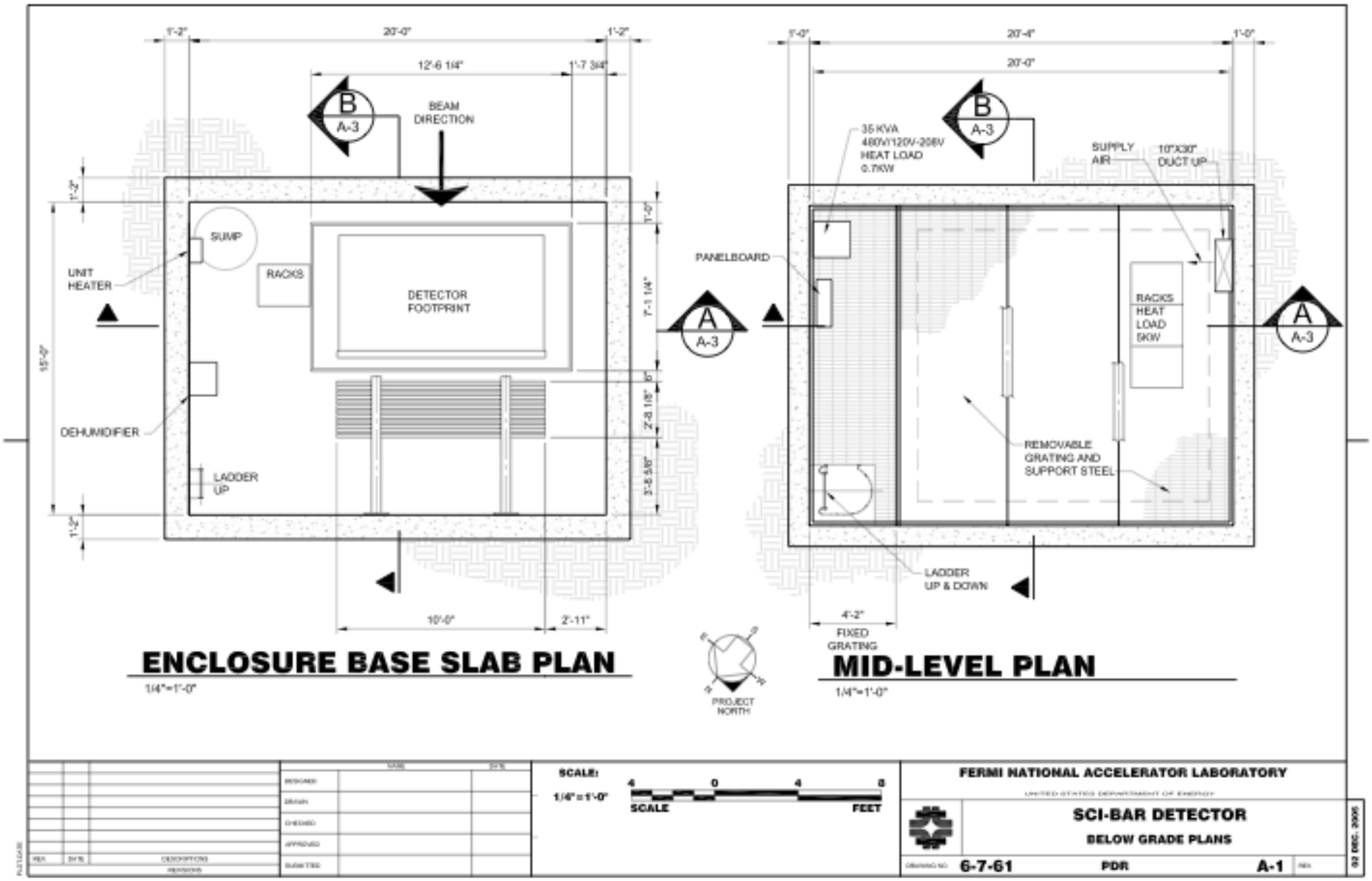


SciBooNE Enclosure Drawings

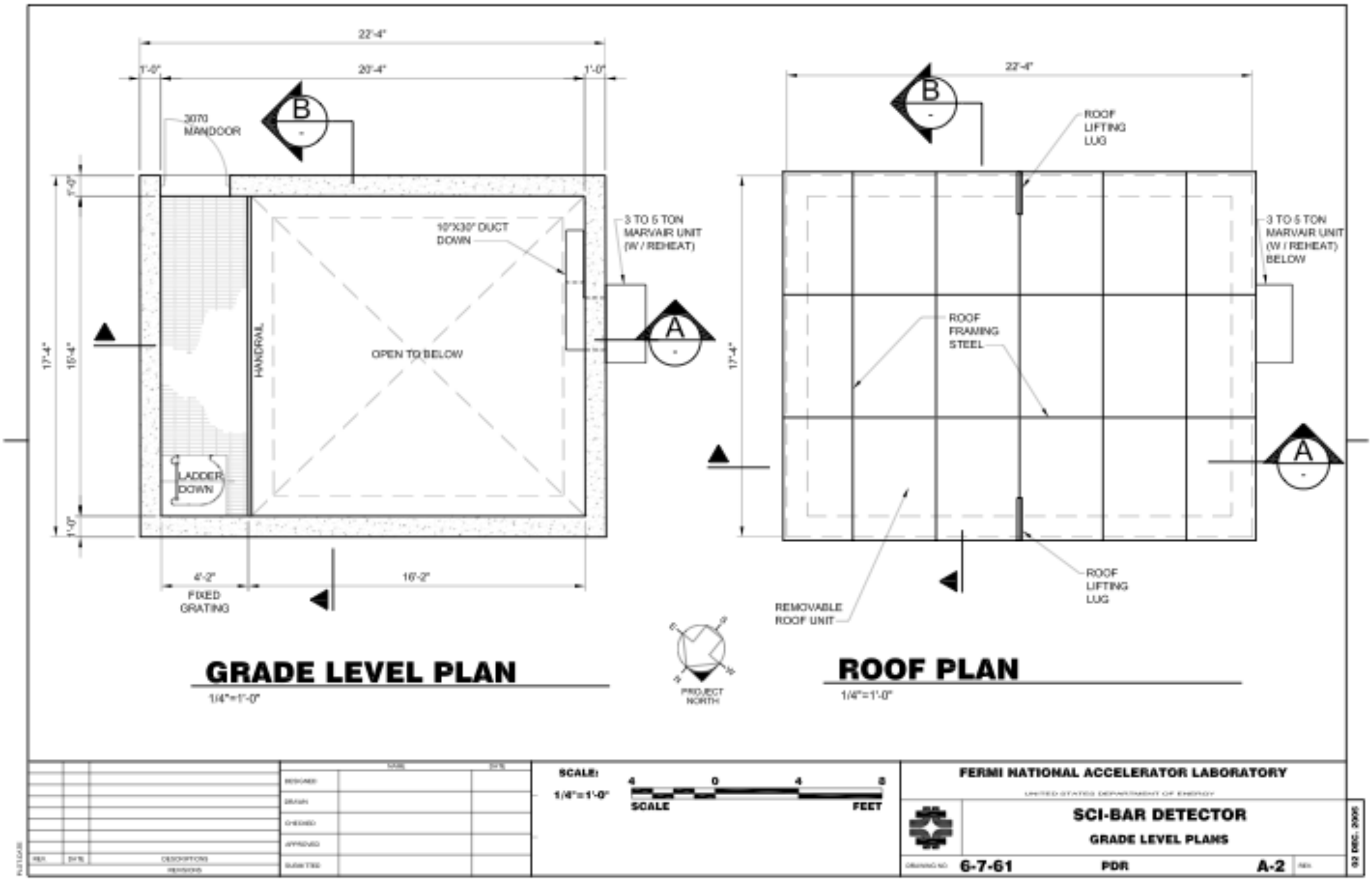


Site Drawing

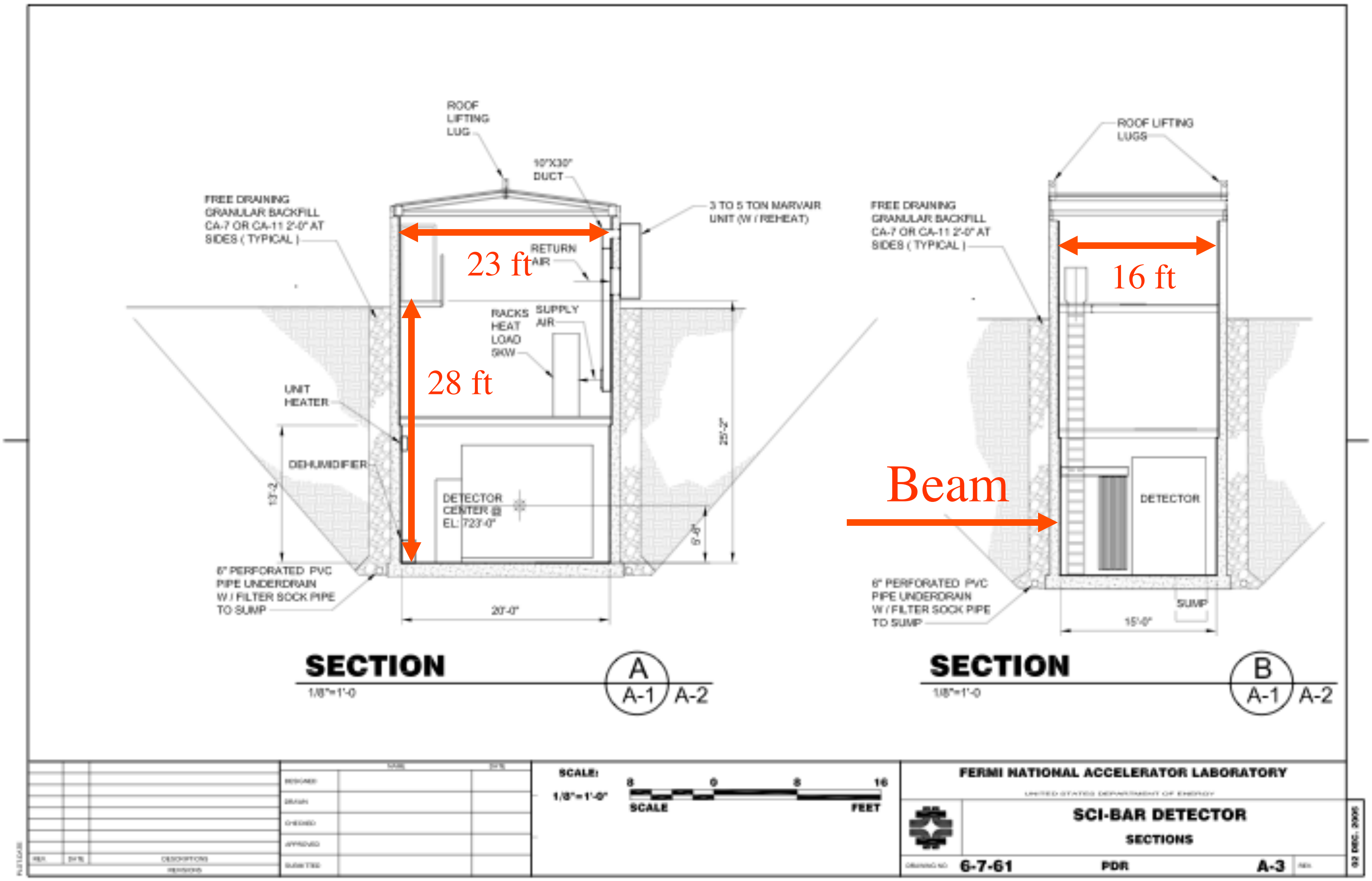
SciBooNE Enclosure Drawings



SciBooNE Enclosure Drawings

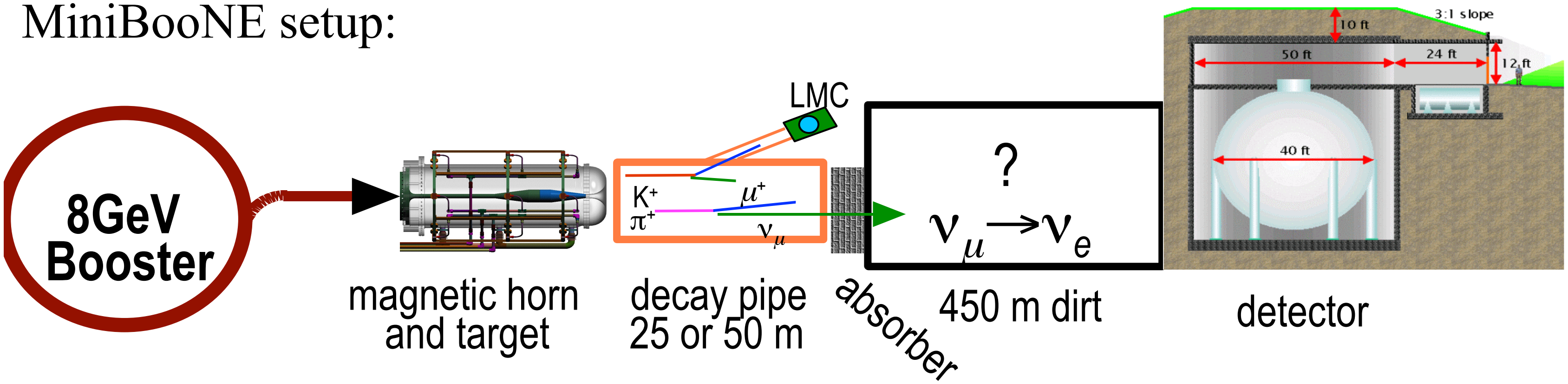


SciBooNE Enclosure Drawings



Booster Neutrino Beam

MiniBooNE setup:



NDOS

8.9 GeV proton beam momentum on Beryllium target.

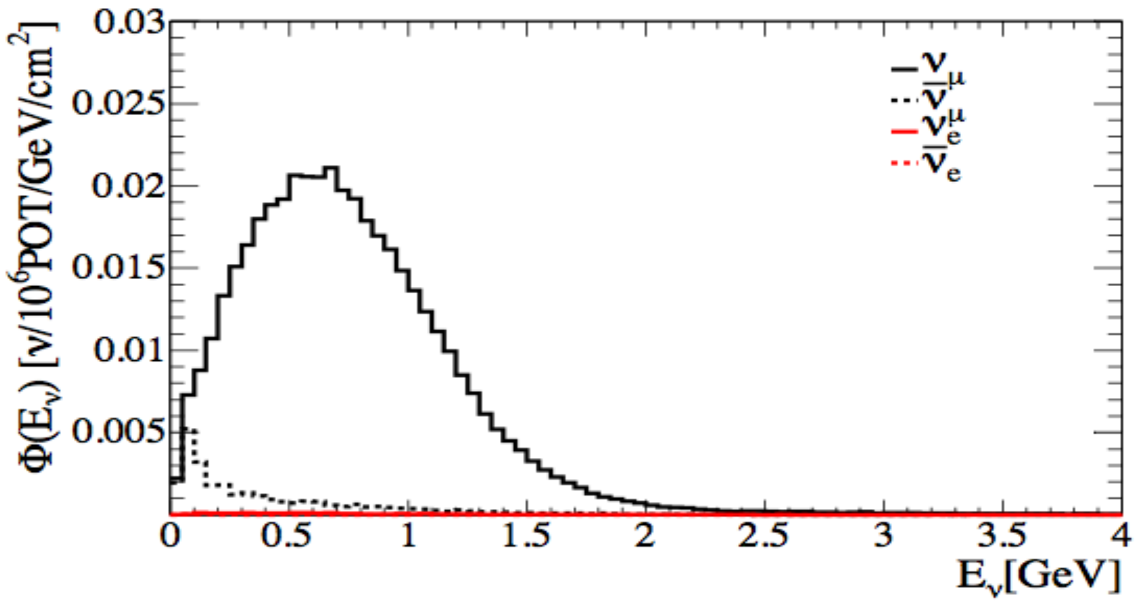
External measurements (HARP, etc) used to describe hadron production.

Neutrino Flux modeled with GEANT4 simulation.

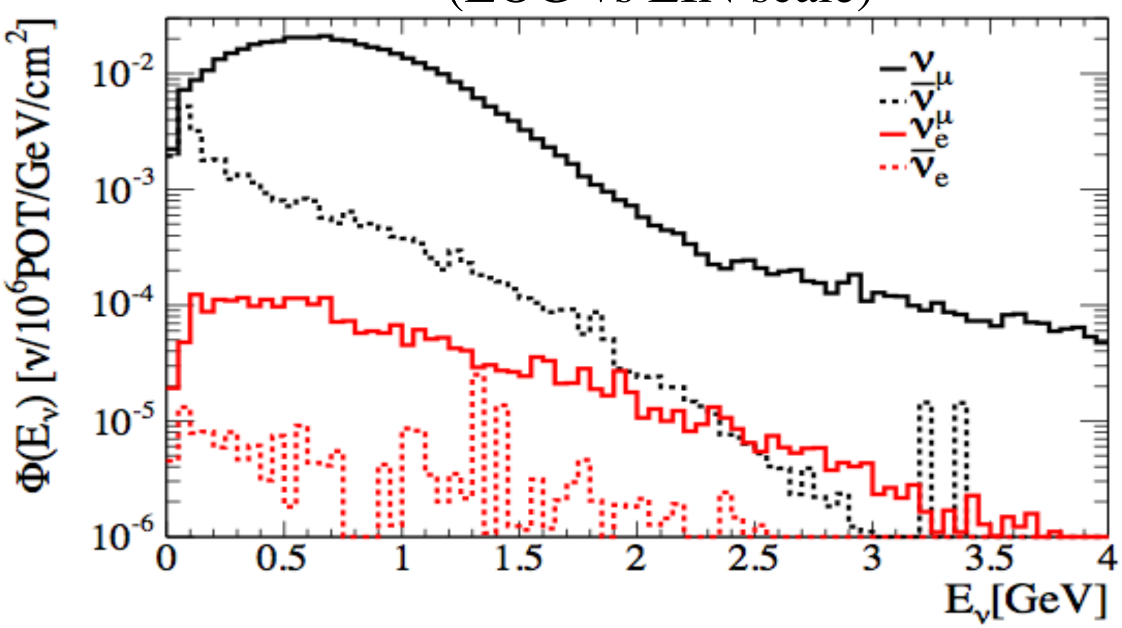
Booster runs in both neutrino and anti-neutrino modes.

Details: "The Neutrino Flux prediction at MiniBooNE", by MiniBooNE Collaboration (A.A. Aguilar-Arevalo et al.),Phys.Rev.D79:072002,2009., arXiv:0806.1449 [hep-ex].

Booster Neutrino Flux at SciBooNE Location



(LOG vs LIN scale)



-neutrino mode flux (the beam also runs in anti-neutrino mode).

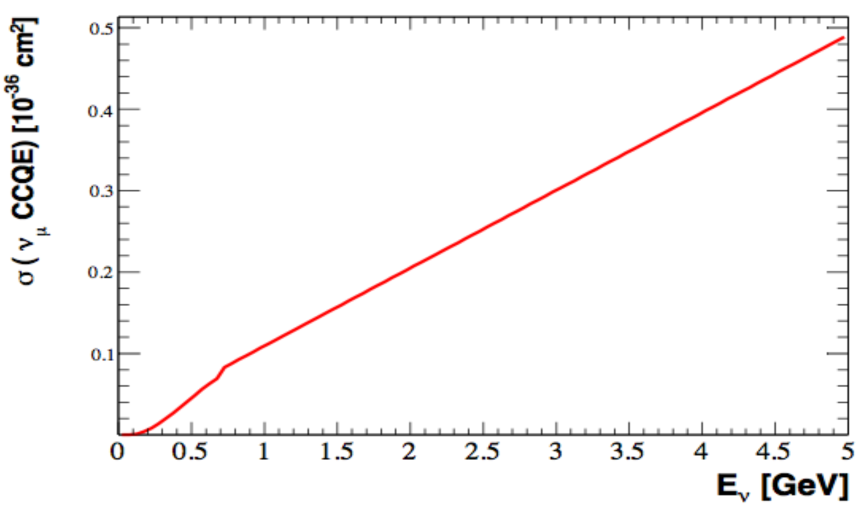
-Flux calculated per unit area [cm^2] per 10^6 protons on Booster target, by averaging over cycle with R=150 cm.

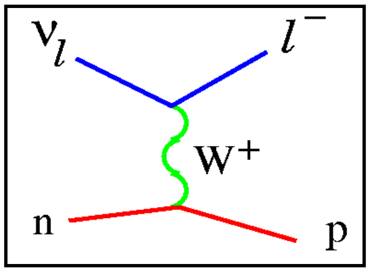
Cross-section for calculating Event Rates

Cross-section generator = Nuance

Nuance describes various neutrino interaction processes on CH_2/H_2O, which include:
-Llewellyn-Smith free nucleon quasi-elastic cross section,
-Rein-Seghal resonant and coherent pion production cross section,
-Smith-Moniz Fermi gas model,
-final state interactions based on π-Carbon scattering data,
-etc.

Example: Cross-section for ν_μ charged current (CC) interaction at CH_2





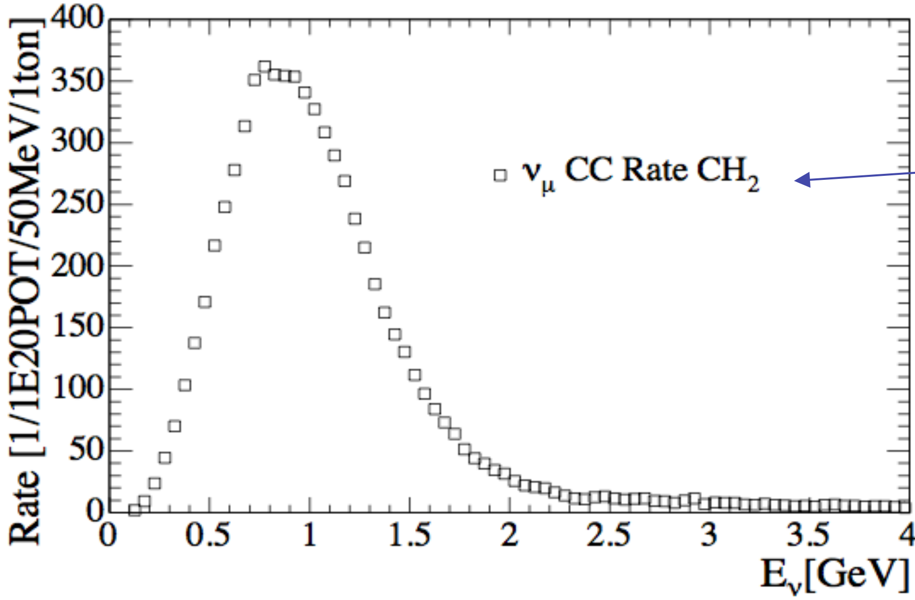
Next pages shows total expected event rate (before reconstruction is applied), including all interaction channels for $1x10^{20}$ POT exposure.

Assumed:
Mass = 1 ton (just multiply to desired tonnage).

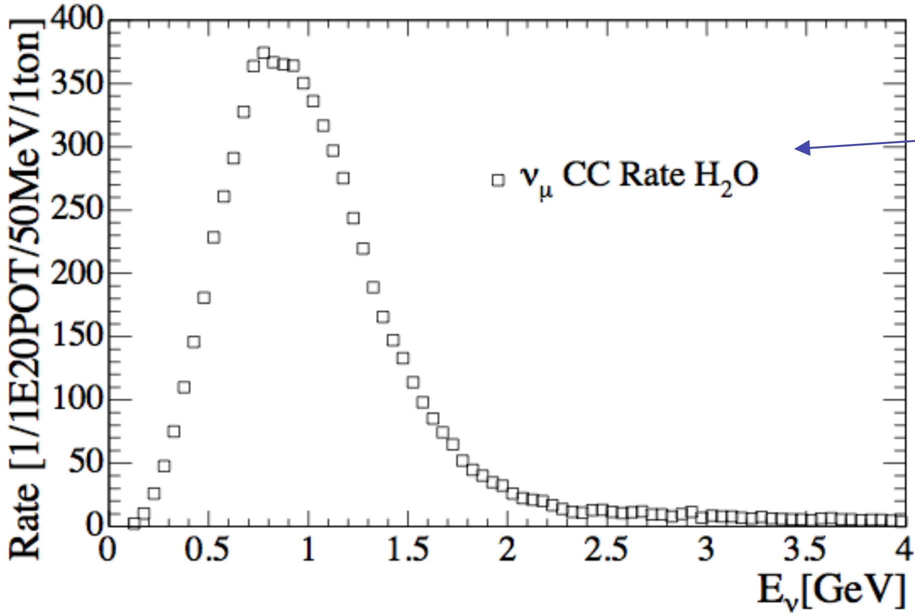
Target = CH_2 , density = 0.855 g/cm^3, or
Target =H_2O, density = 1.0 g/cm^3.
Cross-section generator = Nuance

Event Rates

-Calculate event rates (flux x cross-section)



Calculated ν_μ charged current (CC) rate in 1 ton CH_2 detector when exposed to Booster beam in ν mode with 10^{20} POT
7265 events expected in this channel



Calculated ν_μ charged current (CC) rate in 1 ton H_2O detector when exposed to Booster beam in ν mode with 10^{20} POT
7443 events expected in this channel

for particular interaction channel (CC).

Rates Expected with 1×10^{20} POT exposure

	Total Events [1/1ton/10^{20}POT]	ν-type	Total (per ν-type)	Charged Current	Neutral Current
Booster Beam (ν-mode, Target = CH_2)	10419	ν_μ	10210	7265	2945
		anti-ν_μ	133	88	45
		ν_e	72	52	20
		anti-ν_e	4.4	3	1.4
Booster Beam (ν-mode, Target = H_2O)	10612	ν_μ	10405	7443	2962
		anti-ν_μ	129	85	44
		ν_e	73	53	20
		anti-ν_e	4.6	3.0	1.6

What to expect in a run with LAPD prototype at SciBooNE location?

-Currently Booster delivers ~$1.2x10^{20}$ POT/year.
-In 2013 the Booster will be running for MicroBooNE. They expect ~(2 to 3)$x10^{20}$ POT/year.
-Booster beam will (most likely) run in neutrino mode.
-In the calculations performed the flux uncertainty is 10%, the cross-section uncertainties are more than 10%.
-Easy to calculate flux and event rates in anti-neutrino mode (not done here). Rates would be ~5 times lower in anti-neutrino mode when compared to neutrino mode.

Goals (not in the particular order)

-Measure neutrino cross-sections in water (important for LBNE); essentially unmeasured in this energy range.
-Measure neutron yield in neutrino interactions (bkg from atmospheric neutrino interactions -> proton decay).
-Use both water and water-based LS (LS can detect muons below muon’s cherenkow threshold in pure H_2O, etc).
-Do all this with new LAPPDs.